

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



(51) International Patent Classification 6 : C12N 15/45, A61K 31/70, 39/175		A1	(11) International Publication Number: WO 97/41236
			(43) International Publication Date: 6 November 1997 (06.11.97)
(21) International Application Number: PCT/IB97/00444		(81) Designated States: AU, CA, JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(22) International Filing Date: 28 April 1997 (28.04.97)		Published With international search report.	
(30) Priority Data: 96810273.1 29 April 1996 (29.04.96) EP			
(34) Countries for which the regional or international application was filed: AT et al.			
(71)(72) Applicants and Inventors: ZURBRIGGEN, Andreas [CH/CH]; Mühlestrasse 158, CH-3053 Münchenbuchsee (CH). WITTEK, Riccardo [CH/CH]; Chemin de la Mésange 1A, CH-1302 Vufflens-la-Ville (CH).			
(74) Agent: E. BLUM & CO.; Vorderberg 11, CH-8044 Zürich (CH).			
(54) Title: POLYNUCLEOTIDE VACCINE AGAINST CANINE DISTEMPER			
(57) Abstract			
Disclosed are polynucleotide vaccines against the canine distemper virus, methods of preparation of the polynucleotides and the vaccines, and the use of the polynucleotides and the vaccines for prophylactic immunization of mammals susceptible to canine distemper.			
CNW-IE			

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

POLYNUCLEOTIDE VACCINE AGAINST CANINE DISTEMPER

Technical Field

5

The invention concerns polynucleotide vaccines against the canine distemper virus (CDV), methods of preparation of the polynucleotides and the vaccines comprising them, and the use of the polynucleotides as
10 vaccines for prophylactic immunization of animals susceptible to canine distemper.

Background Art

15 Canine distemper is a highly infectious, acute or subacute, febrile viral disease of dogs and other carnivores, which occurs world-wide. Some dogs show primarily respiratory signs, others intestinal signs and at least 30% of the animals develop neurological symptoms.
20 All experimentally infected dogs have histopathological lesions in the central nervous system. The mortality rate ranges between 30 and 80%. In a minority of cases, dogs that have recovered continue to harbour the virus in brain cells where it replicates slowly and
25 eventually produces old dog encephalitis. The situation is analogous to that of subacute sclerosing panencephalitis in the corresponding human infection, measles. Dogs surviving distemper have life-long immunity to re-infection. Immunization is recommended for the control of
30 distemper in dogs, using attenuated live virus vaccines at the age of 8 weeks and again at 12 to 16 weeks. Annual re-vaccination is recommended.

The importance of effective vaccines against morbillivirus infections is emphasized by recent reports
35 on the discovery of new members of this virus group, affecting both terrestrial and marine mammals (Kennedy et al. 1988; Domingo et al. 1991). There have been several

outbreaks of canine distemper among lions of the Serengeti and lions, tigers and leopards in American zoos (Appel et al. 1994; Leary, 1994). It was surprising, that these big cats are susceptible to CDV. Furthermore, in Australia a disease of horses, acute equine respiratory syndrome (AERS) occurred and it was shown, that the AERS virus belongs to the genus morbillivirus of the paramyxoviridae (Murray, 1994). This virus not only infects horses but is also transmissible to man. Morbilliviruses thus seem to have expanded their host range. Increasing incidence of canine distemper has also been noted in Japan, Finland, Italy and Switzerland despite vaccination. The tested virus isolates were different from vaccine strains, in terms of reactivity with antibodies raised against the vaccine strains (Mori et al. 1994). In Germany and Switzerland CDV infections among wild carnivores have been reported, and mustelids may be a hidden reservoir of CDV (Alldinger et al. 1994). Recent experiments demonstrated CDV-RNA in bone tissues of humans with a chronic bone illness characterized by excessive bone resorption, new bone formation and deformity, the so-called Paget's disease (Gordon et al. 1992). Therefore, CDV has been suggested to be involved in the pathogenesis of Paget's disease. It is well known that CDV can infect bone cells of its natural host (Gordon et al. 1992; Mee et al. 1992). Moreover, bone lesions were observed in young dogs with experimental and spontaneous distemper (Baumgärtner et al. 1995). In addition to acute infections, two members of the morbilliviruses, measles virus and canine distemper virus, also produce a persistent infection.

Canine distemper is caused by CDV, a member of the genus morbillivirus (family paramyxoviridae). CDV is closely related to the viruses of measles and rinderpest.

The canine distemper virions (Fig. 1) are enveloped and contain a negative-strand RNA genome of

15'616 nucleotides which has been entirely sequenced for the cell culture adapted Onderstepoort (OP-CDV) strain (Sidhu et al., 1993, and references therein). The viral genome encodes 6 proteins: the nucleocapsid (N) protein, the phosphoprotein (P), the matrix (M) protein, the fusion (F) protein, the hemagglutinine (H) protein, and the large (L) protein. The genes are arranged in the genomic RNA in the order (3'-5'): N, P, M, F, H, and L and each protein is translated from a unique mRNA transcribed from the negative strand RNA template.

The currently used vaccines against canine distemper have a number of drawbacks. They may induce immunosuppression (M. Vandeveld, University of Berne, pers. comm.) or neurological disorders (cited in Hamburger et al., 1991). Even cases of vaccine-induced distemper have been reported (C. Green, University of Georgia; R. Higgins, University of Davis; R. Maes, University of Michigan, pers. comm.). Furthermore, these vaccines are not particularly satisfactory in terms of efficacy since cases of canine distemper in vaccinated dogs are not rare. Thus, of 84 dogs with diagnosed neurologic distemper, 32 had complete, and 21 partial vaccine coverage (Tipold et al., 1994). The incomplete protection provided by the vaccine strains is most likely the consequence of changes occurring in the virus upon cell culture adaptation. Such changes are demonstrated by the fact that after adaptation to cell lines the virus quickly loses its ability to cause disease (Bittle et al., 1962) and that loss of virulence is associated with structural alterations in the viral nucleocapsid protein (Hamburger et al., 1991). Similarly, the observation that radiolabelled hybridization probes derived from tissue culture-adapted virus failed to detect viral nucleic acids in the brain of animals infected with virulent virus is an indication that the vaccine and virulent strains differ markedly (Mitchell et al., 1987). In view of these differences it is not surprising that immunity induced by vaccine

strains is not able to provide complete protection against virulent virus.

Since the first report of protection of mice against challenge with influenza virus following intramuscular injection of DNA (Ulmer et al., 1993) it has been recognized that injection of naked nucleic acids encoding vaccine antigens represents a potent novel avenue in vaccine development (review: Montgomery et al., 1994). The advantages of nucleic acid vaccines are obvious. Such vaccines should be safe, since no live organisms are used. Furthermore, plasmid DNA is easy and cheap to produce and is stable even in adverse climatic conditions which makes DNA vaccines particularly attractive for developing countries. An additional advantage is that new plasmids can be constructed and tested in a relatively short time which is important for designing vaccines against pathogens for which the protective antigens have not yet been identified. Perhaps the most attractive feature of nucleic acid vaccines is that they induce both antibody and cell-mediated immune responses (Ulmer et al., 1993).

Several methods for delivering DNA are currently available (review: Montgomery et al., 1994). The most convenient method is direct injection into muscle tissue (Wolff et al., 1992).

Disclosure of the invention

Object of the presented invention is to produce novel nucleic acid vaccines against canine distemper which lack the drawbacks of hitherto vaccines against this disease. In particular, said vaccine is a polynucleotide vaccine containing virulent canine distemper virus genes which are important for eliciting neutralizing antibodies, and which are essential for cell-mediated immunity. These genes are to be inserted into expression plasmids which after delivery to living tissues produce

an immunizing effect. It is believed that a nucleic acid vaccine containing genes of virulent distemper virus has significant advantages in terms of efficacy over conventional attenuated vaccine strains which differ markedly from virulent virus. Furthermore, no reversion to virulence, which has been demonstrated for distemper virus vaccine strains (Appel, 1978) and which may result in distemper outbreaks in vaccinated animals is possible (Bush et al., 1976; Carpenter et al., 1976; Hartley et al., 1974). In addition, the inclusion of different genes in combination in the nucleic acid vaccine will generate both a humoral and a cellular immune response. A further advantage of a nucleic acid vaccine against canine distemper is that such a vaccine, in contrast to conventional live vaccine strains, will not induce immunosuppression. This is particularly important when the canine distemper vaccine is administered together with other components in a multivalent vaccine. In this situation, immunosuppression of the host renders other live vaccine components more virulent, possibly resulting in disease induced by these vaccine strains. Immunosuppression by canine distemper vaccine strains also reduces the immune response to inactivated components contained in a multivalent vaccine. A nucleic acid vaccine against canine distemper will not have these undesirable side effects. Thus, the inventive vaccine is in many aspects superior to hitherto known vaccines.

**Brief Description of the Sequence Listings
and the Figures:**

SEQU ID NO 1 shows the primer sequence corresponding to the leader of CDV strain A75/17;

SEQU ID NO 2 shows the primer sequence corresponding to the end of the N gene of CDV strain A75/17;

SEQU ID NO 3 shows the primer sequence corresponding to the M gene at position M 116 of strain OP-CDV;

5 SEQU ID NO 4 shows the primer sequence corresponding to the F gene at position F 1092 of strain OP-CDV;

SEQU ID NO 5 shows the primer sequence corresponding to the F gene at position F 177 of strain OP-CDV;

10 SEQU ID NO 6 shows the primer sequence corresponding to the F gene at position F 2058 of strain OP-CDV;

15 SEQU ID NO 7 shows the primer sequence corresponding to the F gene at position F 2002 of strain OP-CDV;

SEQU ID NO 8 shows the primer sequence corresponding to the H gene at position H 716 of strain OP-CDV;

20 SEQU ID NO 9 shows the primer sequence corresponding to the H gene at position H 675 of strain OP-CDV;

SEQU ID NO 10 shows the primer sequence corresponding to the L gene at position L 78 of strain OP-CDV;

25 SEQU ID NO 11 shows the primer sequence for generating the 5' end of the N gene with a Kpn I restriction site;

30 SEQU ID NO 12 shows the primer sequence for generating the 3' end of the N gene with a Sal I restriction site;

SEQU ID NO 13 shows the primer sequence F1 corresponding to the F gene of strain OP-CDV at position 1 with a Mlu I restriction site;

35 SEQU ID NO 14 shows the primer sequence F2 corresponding to the F gene of strain OP-CDV at position 2033;

SEQU ID NO 15 shows the primer sequence F3 corresponding to the F gene of strain OP-CDV at position 2014;

SEQU ID NO 16 shows the primer sequence F4 corresponding to the F gene of strain OP-CDV at position 2095 with a Sal I restriction site;

SEQU ID NO 17 shows the primer sequence H1 corresponding to the H gene of strain OP-CDV at position 18 with a Kpn I restriction site;

SEQU ID NO 18 shows the primer sequence H2 corresponding to the H gene of strain OP-CDV at position 705;

SEQU ID NO 19 shows the primer sequence H3 corresponding to the H gene of strain OP-CDV at position 684;

SEQU ID NO 20 shows the primer sequence H4 corresponding to the H gene of strain OP-CDV at position 1835 with a Sal I restriction site;

SEQU ID NO 21 shows the sequence corresponding to the N gene of virulent CDV strain A75/17. Position 1 corresponds to 5' end of the N mRNA. The translation initiation (ATG) and termination (TAA) codons are underlined;

SEQU ID NO 22 shows the sequence corresponding to the F gene of virulent CDV strain A75/17. Position 1 corresponds to 5' end of the F mRNA.

SEQU ID NO 23 shows the sequence corresponding to the H gene of virulent CDV strain A75/17. Position 1 corresponds to 5' end of the H mRNA.

Figure 1 shows a schematic representation of the CDV particle. The location of the viral M, H, F, N, P and L proteins are indicated.

Figure 2 shows the expression plasmid H/CMV5 for the CDV H gene of strain A75/17.

Figure 3 shows the expression plasmid H/pCI for the CDV H gene of strain A75/17.

Figure 4 shows the expression plasmid N/CMV5 for the CDV N gene of strain A75/17.

Figure 5 shows the expression plasmid N/pCI for the CDV N gene of strain A75/17.

5 Figure 6 shows the expression plasmid F/CMV5 for the CDV F gene of strain A75/17.

Figure 7 shows the expression plasmid F/pCI for the CDV F gene of strain A75/17.

Figure 8 shows CTL assays of mice immunized with plasmid N/pCI or empty vector after 2nd immunization.

Figure 9 shows CTL assays of mice immunized with plasmid N/pCI or empty vector after 3rd immunization.

15 Figure 10 shows anti-N antibody titers of dogs immunized with standard vaccine or with plasmid N/pCI.

20

Modes for Carrying out the Invention

In one embodiment the invention concerns a nucleic acid construct comprising a canine distemper virus gene, wherein said nucleic acid construct is capable of inducing the expression of an antigenic canine distemper virus gene product which induces a canine distemper virus specific immune response upon introduction of said nucleic acid construct into animal tissue *in vivo* and resultant uptake of the nucleic acid construct by the cells which express the encoded canine distemper virus gene.

30 The nucleic acid construct is a DNA or RNA construct, preferably a DNA construct.

The invention concerns in particular a nucleic acid construct, wherein the canine distemper virus gene encodes the nucleocapsid (N) protein, the phosphoprotein (P), the matrix (M) protein, the fusion (F)

protein, the hemagglutinin (H) protein, or the large (L) protein.

The nucleic acid construct is in particular such, wherein the canine distemper virus gene encodes the nucleocapsid (N) protein, the fusion (F) protein, or the
5 hemagglutinin (H) protein.

Preferred DNA constructs are the plasmids H/CMV5 and H/pCI, which encode the hemagglutinin (H) protein, the plasmids F/CMV5 and F/pCI, which encode the fusion (F) protein of canine distemper virus strain A75/17,
10 and in particular the plasmids N/CMV5 and N/pCI, which encode the nucleocapsid (N) protein, .

Nucleic acids coding for polypeptides of the wild-type strain A75/17 and expression vectors for the
15 expression of such polypeptides *in vivo* are of particular importance because this strain induces distemper.

The present nucleic acid constructs are in particular expression plasmids comprising at least one and preferably one of the canine distemper genes operatively linked to a promoter and optionally to other sequences improving the expression of the gene, e.g. such
20 as an enhancer, as well as an appropriate terminator sequence. Expression plasmids comprising such functional sequences necessary for expression of the gene are known
25 in the art, and are e.g. plasmids CMV5 and pCI.

In another embodiment the invention concerns a polynucleotide vaccine comprising an effective amount of a nucleic acid construct, e.g. a DNA or RNA construct, and a physiologically acceptable carrier. Said vaccine
30 induces neutralizing antibodies against canine distemper virus, canine distemper virus specific cytotoxic lymphocytes, or protective immune responses upon introduction thereof into animal tissue *in vivo*, wherein said animal is a mammal, a human, and in particular a dog.

35 In particular preferred is a polynucleotide vaccine comprising one or more of the plasmids selected from N/CMV5 or N/pCI, which encode the nucleocapsid (N)

protein, H/CMV5 or H/pCI, which encode the hemagglutinin (H) protein, or F/CMV5 or F/pCI which encode the fusion (F) protein of the virulent canine distemper virus strain A75/17, and a physiologically acceptable carrier.

5 Physiologically acceptable vaccine carriers are known in the art and are e.g. physiologically acceptable injectable fluids, such as buffer solutions, e.g. phosphate-buffered saline (PBS) of appropriate pH, preferably of between about 7 to about 7.4, or injectable
10 liposome preparations. The vaccine may also contain an adjuvant or a transfection facilitating agent. The vaccine comprises an effective, that is an immunizing amount of a nucleic acid construct of the present invention, or a combination of two or more constructs, e.g. in a con-
15 centration of about 0.01 to 100, preferably about 0.1 to 1 mg /ml.

In yet another aspect of the invention one or more inventive constructs, each of which is carrying at least one of the canine distemper genes, are components
20 of a multivalent vaccine. The components of said multivalent vaccine can be packed in admixed form or one or more components can be packed separately from other components but are administered either together, i.e. after mixing, or separately but almost simultaneously, i.e. a
25 second administration directly after a first one.

In another embodiment the invention concerns a method for protecting an animal susceptible to infection by canine distemper virus which comprises immunization of said animal with a prophylactically effective
30 amount of at least one polynucleotide construct comprising a gene of canine distemper virus optionally together or simultaneously with at least one other component as a multivalent vaccine.

A number of animals are known as being susceptible to canine distemper virus. Such animals are in
35 particular mammals, such as carnivores, in particular dogs, and also humans.

In particular preferred is the method, wherein the polynucleotide is administered directly into tissue, preferably into muscle tissue, *in vivo*. The polynucleotide may be administered either in naked form in a physiologically acceptable solution, or contained in a liposome, or in a mixture with an adjuvant or a transfection facilitating agent. In particular preferred is the method of using a vaccine according to the present invention.

10 In another embodiment the invention concerns a method for using a canine distemper virus gene to induce an immune response *in vivo* which comprises:

- a) isolating the gene
- b) linking the gene to regulatory sequences
- 15 such that the gene is operatively linked to control sequences which, when introduced into a living tissue, direct the transcription of the gene and subsequent translation of the mRNA, and

c) introducing the gene into a living tissue.
20 In particular preferred is the method, which comprises multiple introduction of the canine distemper gene for boosting the immune response.

In particular preferred is the method, wherein the canine distemper gene encodes the nucleocapsid (N) protein, the hemagglutinin (H) protein, or the fusion (F) protein of canine distemper virus strain A75/17.

In particular preferred is the method, wherein the canine distemper gene product for immunization is selected from the plasmids F/CMV5 or F/pCI, H/MCV5 or 30 H/pCI, N/CMV5 or N/pCI which encode proteins of the wild type canine distemper virus strain A75/17, or a combination of those plasmids.

In another embodiment the invention concerns a composition of nucleic acid constructs encoding CDV genes from more than one canine distemper virus strain.

In another embodiment the invention concerns the use of an isolated canine distemper gene operatively

linked to one or more control sequences for the preparation of a vaccine for use in immunization against infection by CDV.

The following examples serve to further describe the invention, however, they should not be construed as a limitation thereof.

Example 1: Preparation of cDNA clones from canine distemper virus strain A75/17 (wild type) infected primary dog brain cell cultures

a) Preparation of cytoplasmic RNA

Primary dog brain cell cultures (DBCC) were prepared as described by Zurbriggen and Vandeveld, 1984.

DBCC were infected 10-14 days after seeding, when confluency was reached, with the virulent canine distemper virus strain A75/17 (Zurbriggen et al., 1993).

About 40 days after infection, RNA was prepared from infected DBCC grown in 9-cm diameter cell culture petri dishes as follows: The medium was removed and replaced by 1ml of ice-cold buffer A (150 mM NaCl, 1.5 mM MgCl₂, 10mM Tris, pH 7.8) The cells were scraped off with a rubber policeman and transferred to a centrifuge tube. The tube was kept on ice for 10 min and then centrifuged for 3 min at 1000 x g. The supernatant was transferred to a new tube. The pellet was resuspended in 1ml of ice-cold buffer A and again centrifuged for 3 min at 1000 x g. The supernatant was combined with the first. To the combined supernatants, 2 ml of 7 M urea, 350 mM NaCl, 10 mM EDTA, 10 mM Tris pH 7.9, 1% SDS was added. The obtained mixture was extracted with 4 ml of phenol-chloroform (1:1) and the resulting aqueous phase treated with 3 volumes of EtOH. The precipitated RNA was centrifuged and suspended in 100 µl of PBS.

b) Synthesis of cDNA

A series of overlapping cDNA clones from the CDV genome was obtained as outlined below. The procedure is described for generating clones containing the entire N, F and H gene sequences. The M, P and L genes may be isolated in the same manner using specific primers for these genes.

c) First strand cDNA

Primers used for first strand cDNA synthesis were selected on the basis of the published sequence of the OP-CDV vaccine strain (Sidhu et al., 1993). They are located in regions which are highly conserved in Morbilliviruses. The 10 primers used and their sequence identification numbers SEQ ID NO 1 to 10 are given hereinafter.

Reaction mixtures for cDNA synthesis contained: 24.5 μ l H₂O, 10 μ l 5X AMV reverse transcription buffer, 1 μ l of a 75 μ M dNTP solution, 2.5 μ l of a 40 μ M primer solution, 1 μ l RNase inhibitor, 1 μ l AMV reverse transcriptase (5 units/ μ l), 10 μ l of the above obtained RNA/PBS solution. Samples were incubated for 2 h at 42°C and then heated at 75°C for 10 min.

e) Synthesis of double stranded cDNA

Double stranded cDNA was synthesized using polymerase chain reaction (PCR). Reaction mixtures for amplification of a specific region of the CDV genome contained both the 3' and 5' primers (see SEQ ID NOs). Synthesis was performed in a volume of 100 μ l and contained the following: 77.4 μ l H₂O, 10 μ l 10X Taq buffer, 1.1 μ l of a solution containing all 4 dNTPs at 20 μ M each, 0.5 μ l of a 40 μ M primer solution, 1 μ l of Taq polymerase (0.5 units/ μ l) and 10 μ l of first strand cDNA, heated to 75°C for 10 min and then cooled on ice. PCR reactions were performed for 30 cycles under standard conditions.

f) Cloning of cDNA

PCR amplified cDNA was cloned into the pCR II vector (Invitrogen) using standard conditions (Sambrook et al., 1989).

5 g) Assembly of contiguous genes

The procedure described above for producing cDNA clones resulted in the isolation of the complete N gene.

For the F and H genes, a series of overlapping clones was obtained. To assemble these genes into contiguous DNA segments, recombinant PCR (Ho et al., 1989) was used.

Example 2: Preparation of the N Gene

15 Appropriate 5' and 3' ends for insertion of the N gene into expression plasmids were generated by PCR. The following primers were used:

N1, SEQ ID NO 11: 5' GGG GTA CCT CAG GGT TCA
GAC CTA CCA 3', for generating the 5' end of the gene;

20 and

N2, SEQ ID NO 12: 5' GCG TCG ACG ACT GAT GTA
ACA CTG GTC T 3', for generating the 3' end.

This created KpnI and SalI sites at the 5' and 3' ends, respectively. PCR reactions were performed
25 under standard conditions.

Example 3: Preparation of the F Gene

The primers F1-F4 used in this experiment were designed according to partial sequences of the
30 A75/17. However, the positions of the underlined nucleotides correspond to the positions of the of the OP-CDV genes according to Barrett et al., 1987. The primers were synthesized with a nucleic acid synthesizer machine.

35 F1, SEQ ID NO 13: 5' CGA CGC GTA GGG TCC AGG
ACG TAG CA 3', position 1;

F2, SEQ ID NO 14: 5' CAG GTT TAA ATG TCG GAT
CG 3', position 2033;

F3, SEQ ID NO 15: 5' CGA TCC GAC ATT TAA ACC
TG 3', position 2014;

5 F4, SEQ ID NO 16: 5' GCGTCG ACA AGA CGT GTG
ACC AGA GTG 3', position 2095.

The F gene was isolated as 3 overlapping
clones. First, the 5' portion of the gene was assembled.
10 A first cDNA clone containing parts of the M and F genes
was cleaved with SacI in the vector DNA and with HindIII
at position 687 in the F gene and the fragment of 2035 bp
was isolated. A second cDNA clone, containing most of the
F gene coding sequences in reverse orientation with re-
15 spect to the first clone, was also cleaved with HindIII
and SacI. The 1405 bp fragment was isolated. Both frag-
ments were ligated into the pBluescript (Stratagene, La
Jolla, CA) plasmid cleaved with SacI. To add the 3' end
of the F gene, and to generate correct 5' and 3' ends for
20 cloning into expression plasmids, PCR was used. The 5'
portion of the gene was amplified by PCR using primers F1
(5' CGA CGC GTA GGG TCC AGG ACG TAG CA 3') and F2 (5' CAG
GTT TAA ATG TCG GAT CG 3') and the DNA fragment was puri-
fied by gel electrophoresis on an agarose gel. Similarly,
25 the 3' portion of the gene was amplified by PCR with
primers F3 (5' CGA TCC GAC ATT TAA ACC TG 3') and F4 (5'
GCGTCG ACA AGA CGT GTG ACC AGA GTG 3') and purified. Fi-
nally, the two parts of the gene were assembled by recom-
binant PCR using the gel purified 5' and 3' portions of
30 the gene and primers F1 and F4. This allowed to synthe-
size the entire F gene as 1 contiguous DNA segment with
Mlu I and Sal I sites at the 5' and 3' ends, respec-
tively, for cloning into expression plasmids.

35

Example 4: Preparation of the H Gene

The primers H1-H4 used in this experiment
were designed according to partial sequences of the

A75/17 genome. However, the positions of the underlined nucleotides correspond to the positions of the OP-CDV genes according to Curran et al., 1991. The primers were synthesized with a nucleic acid synthesizer machine.

5

H1, SEQ ID NO 17: 5' GCG GTA CCA CAA TGC TCT CCT ACC AG 3', position 18;

H2, SEQ ID NO 18: 5' CAT ACA CTC CGT CTG AGA TAG C 3', position 705;

10

H3, SEQ ID NO 19: 5' GCT ATC TCA GAC GGA GTG TAT G 3', position 684;

H4, SEQ ID NO 20: 5' GCG TCG ACT TAA CGG TTA CAT GAG AAT CT 3', position 1835:

15

The H gene coding sequences were cloned as 2 overlapping cDNA clones. The gene was assembled by PCR technology. First, the 5' portion of the gene was amplified by PCR using primers H1 (5' GCG GTA CCA CAA TGC TCT CCT ACC AG 3') and H2 (5' CAT ACA CTC CGT CTG AGA TAG C 3') and the resulting DNA fragment was isolated. The 3' portion of the gene was amplified with primers H3 (5' GCT ATC TCA GAC GGA GTG TAT G 3') and H4 (5' GCG TCG ACT TAA CGG TTA CAT GAG AAT CT 3') and the DNA fragment was also isolated. The two portions of the gene were fused in a recombinant PCR reaction containing both DNA fragments and primers H1 and H4. This resulted in the synthesis of a DNA fragment containing the entire H gene coding sequences with a KpnI site at the 5' end and a SalI site at the 3' end for cloning into expression plasmids.

25

Example 5: Cloning into eukaryotic expression plasmids

The recombinant PCR products were purified by gel electrophoresis on an agarose gel. The ends were rendered blunt by Klenov polymerase and the fragments were cloned into the EcoRV site of the plasmid pBluescript (Stratagene, La Jolla, CA) and amplified. The inserts

30

were isolated from plasmids containing the F gene by digestion with MluI and SalI and from plasmids harboring the N and H genes by KpnI and SalI.

The fragments were then cloned either into the plasmid pCI (Promega) or into plasmid pCMV-5 (Andersson et al., 1989). The obtained expression plasmids F/CMV5, F/pCI, H/CMV5, HCPI, N/MCV5 and N/pCI were purified according to standard methods and are shown in Figures 2 to 7.

10

Example 6: Preparation of vaccines

Vaccines are prepared by dissolving one or more of the obtained expression plasmids in sterilized PBS of pH 7.4 in a concentration of 1 mg/ml. The vaccine solution may be freshly prepared just before use or filled under sterile conditions in vials of appropriate size.

20

Example 7: Antibody response in mice immunized with N/pCI

The immune response following intramuscular injection of plasmid N/pCI was tested in mice. Two independent experiments were performed. In the first one (Table 1, Experiment No. I), 5 Balb-c mice were injected with plasmid N/pCI purified by the Qiagen procedure (Qiagen Inc, Chatsworth, CA, USA) according to the instructions of the supplier. Five mice were injected with empty vector DNA purified in the same manner. As a further control, 5 animals were injected with PBS alone. In the second experiment (Experiment No. II) 5 mice were injected with plasmid pCI/N purified by cesium chloride gradient centrifugation (Sambrook et al., 1989) and 5 mice with empty vector DNA purified by the same procedure. In both experiments each animal was injected with 100 µg of DNA in PBS at a concentration of 1 mg/ml, receiving 50 µg in each quadriceps muscle per inoculation.

A total of 4 inoculations were performed at biweekly intervals. Two weeks after the last injection the animals were sacrificed and the serum was collected.

Antibody titers were determined by ELISA using serially diluted mouse sera. Maxisorp ELISA plates (Nunc, Roskilde, Denmark) were coated with 50 ng of recombinant N protein per well in carbonate/bicarbonate buffer (15 mM Na_2CO_3 , 35 mM NaHCO_3 , 0.02% NaN_3 , pH 9.6) at 4°C for 16 hours. After 3 washes with TBS-T (137 mM NaCl, 2.68 mM KCl, 24.7 mM Tris, 0.05 % Tween-20; pH 7.5) the plates were blocked at room temperature for 60 min with PBS-T/LM (PBS containing 0.05% Tween-20 and 2% low fat milk powder. The plates were subsequently washed 3 times with TBS-T before adding 50 µl of the mouse sera diluted in PBS-T/LM. After incubation at 37°C for 60 min. and 3 washes with TBS-T, horseradish peroxidase-labelled goat anti-mouse IgG (Sigma, St. Louis, MO, USA), diluted 1000-fold in PBS-T/LM was added as the secondary antibody. The plates were incubated at 37°C for 60 min and then washed 3 times with TBS-T. Finally, 50 µl of a solution of 1 mg/ml of 1,2 phenylene-diamine in 0.1 M Na-citrate, pH 5.0, containing 0.001 volumes of 30% H_2O_2 was added per well. The reaction was stopped with 50 µl of 4 M H_2SO_4 per well, and the optical density was read at a wave length of 490 nm in a Microplate reader 3550 (Bio-Rad Laboratories, Hercules, CA, USA).

The results (Table 1) show that in contrast to control animals, all animals injected with plasmid N/pCI had significant anti-N antibody titers of up to 1:25'600. Intramuscular injection of plasmid N/pCI thus induces a good immune response, demonstrating the usefulness of the proposed vaccine for protecting animals against canine distemper.

Table 1: Anti-N antibody titers in mice injected with plasmid N/pCI

Experiment No.	Treatment	Exp.-Mouse No.	Titer
I	PBS	I-1	< 1 : 50
		I-2	< 1 : 50
		I-3	< 1 : 50
		I-4	< 1 : 50
		I-5	< 1 : 50
I	pCI	I-6	1 : 200
		I-7	1 : 200
		I-8	1 : 200
		I-9	1 : 200
		I-10	1 : 200
I	N/pCI	I-11	1 : 800
		I-12	1 : 1600
		I-13	1 : 3200
		I-14	1 : 6400
		I-15	1 : 25600
II	pCI	II-1	< 1 : 50
		II-2	< 1 : 50
		II-3	< 1 : 50
		II-4	< 1 : 50
		II-5	< 1 : 50
II	N/pCI	II-6	1 : 3200
		II-7	1 : 1600
		II-8	1 : 200
		II-9	1 : 12800
		II-10	1 : 3200

Example 8: CTL response in mice immunized
with N/pCI

Groups of 4 mice were immunized by either 1,
5 2, or 3 intramuscular injections at 21-day intervals with
a total of 100 µg of plasmid N/pCI. Control animals were
injected with empty vector. Twelve days after the first,
second, or third injection the mice were sacrificed and
the spleen was removed. Splenocytes were isolated using a
10 cell strainer and resuspended in DMEM supplemented with
5% heat-inactivated fetal calf serum, 100 µg/ml penicil-
lin, 100 U/ml streptomycin, 0.05 mM β-mercaptoethanol, 10
mM HEPES, and non-essential amino acids. The cells were
then stimulated by incubation with a synthetic 9 amino
15 acid peptide (YPALGLHEF) which has been shown to repre-
sent a CTL epitope in the measles virus N protein
(Beauverger et al., 1993) and which is conserved in CDV
strains Onderstepoort and A75/17. The peptide was used at
a concentration of 10 µM. After 5-7 days the cells were
20 counted in Trypan blue and adjusted to 2×10^6 viable
cells/ml. The cells were then diluted into microtiter
plates to yield effector to target cell ratios ranging
from 100:1 to 0.1:1.

P 815 mastocytoma cells were used as targets
25 for the CTL assay. Briefly, 10^6 cells were incubated for
1 hour at room temperature with the CTL peptide at a fi-
nal concentration of 1 µM. Control cells were incubated
in the absence of the peptide. After incubation, the
cells were centrifuged and resuspended in 100 µl of me-
30 dium. Then, 100-150 µCi of ^{51}Cr was added and the cells
were incubated for 1 hour at 37°C with occasional shak-
ing. The cells were then washed extensively before adding
 2×10^3 target cells per well of effector cells. Target
and effector cells were incubated 37°C for 4-5 hours. The
35 plates were then centrifuged and from each well 100 µl of
medium was removed and the radioactivity was counted in a
gamma counter. The radioactivity released by control

cells incubated without the CTL peptide was subtracted from the value obtained from cells incubated with the peptide. The resulting value was used to calculate percentage specific lysis.

5 No CTL response was observed after a single immunization (not shown). Importantly, however, after 2 and 3 injections of plasmid N/pCI all mice showed high CTL activity. In contrast, control mice immunized with the empty vector showed very little CTL activity (Fig. 8). Fig. 8 represents CTL assay of mice immunized with plasmid N/pCI or with empty plasmid. Per cent specific lysis was obtained by subtracting the value of non specific lysis of target cells incubated with effector cells in the absence of the CTL peptide. Each curve represents the values obtained with splenocytes from one mouse. Solid line: mice immunized with plasmid N/pCI; broken line: mice immunized with empty vector. The effector (E) to target (T) cell ratio is indicated.

20

Example 9: Immunization of dogs with N/pCI

Beagle dogs of 6 weeks of age were used for immunization experiments. Five control animals (Fig. 9, dogs 1-5) received intramuscular injections of a commercially available multivalent vaccine (standard vaccine) containing inactivated canine adenovirus, parainflunza virus, parvovirus, leptospira and live CDV Onderstepoort strain. Ten dogs (dogs 6-15) were injected into one quadriceps muscle with 100 µg of plasmid N/pCI. Standard vaccine lacking the CDV component was injected into the other quadriceps. A total of 3 injections were performed at 2-week intervals. Before the first, and 2 weeks after each injection (I-III) blood samples were drawn and anti-N antibody levels were determined by ELISA using recombinant CDV N protein as antigen as described for ELISA assays in mice. With standard vaccine, anti N antibody

titers were already elevated with respect to the pre-immune serum after the first vaccination and then reached a plateau. With plasmid N/pCI, in most animals the titers were low after the first and second injection. However, after the third injection, the titers increased and in some animals reached values similar to those obtained with standard vaccine.

The results obtained are visualized in Figure 9. Titers were determined 2 weeks after the first (I), second (II), or third (III) immunization and are represented as the highest serum dilution in which the OD value measured in the ELISA assay was at least twice as high as the value of the corresponding pre-immune serum at the same dilution.

A toxicity test was performed according to the description of the European Pharmacopoeia. Five healthy mice and two healthy guinea pigs were injected with the polynucleotide vaccine as described above. The animals were observed for 7 days. None of the animals showed local or systemic reactions.

REFERENCES

- Alldinger, S., van Moll, P., Baumgärtner, W. and Adami, M. (1994): Distemper in wild carnivores: an epidemiological, histological and immunocytochemical study. Int. Symposium on Morbillivirus Infections, Hannover.
- Andersson, S., Davis, D. N., Dahlback, H., Jornvall, H. and Russel, D. W. (1989): Cloning, structure, and expression of the mitochondrial cytochrome P-450 sterol 26-hydroxylase, a bile acid biosynthetic enzyme. J. Biol Chem. 264, 8222-8229.

Appel, M. J. G. (1978): Reversion to virulence of attenuated canine distemper virus in vivo and in vitro. *J. gen. Virol.* 41, 385-393.

- Appel, M. J. G., Yates, R. A. and Foley, G. L. (1994): Canine distemper epizootic in lions, tigers and leopards in North America. *J. Vet Diagn. Invest* 6, 277-288.

- Barrett, T., Clarke, D. K., Evans, S. A. and Rima, B. K. (1987): The nucleotide sequence of the gene encoding the F protein of canine distemper virus: a comparison of the deduced amino acid sequence with other paramyxoviruses. *Virus. Res.* 8:373-386.

- Baumgärtner, W., Boyce, R. W., Weisbrode, S. E., Alldinger, S., Axthelm, M. K. and Krakowka, S. (1995): Histological and immunocytochemical characterization of canine distemper-associated metaphyseal bone lesions in young dogs following experimental infection. *J. Bone Miner. Res.* submitted.

- Beauverger, P., Buckland, R. and Wild, T.F. (1993): Measles virus antigens induce both type-specific and canine distemper virus cross-reactive cytotoxic T lymphocytes in mice: localization of a common Ld-restricted nucleoprotein epitope. *J. gen. Virol.* 74, 2357-2363.

- Bittle, J., York, Ch. and Newberne, J. (1961): Modification of a strain of canine distemper virus in tissue culture. *Cornell Vet.* 51, 359-369.

- Bush, M., Montali, R. J., Brownstein, D., James, A. E., Jr. and Appel, M. J. (1976): Vaccine-induced canine distemper in a lesser panda. *J. Am. Vet. Med. Assoc.* 169, 959-960.

- Carpenter, J. W., Appel, M. J., Erickson, R. C. and Novilla, M. N. (1976): Fatal vaccine-induced canine distemper virus infection in black-footed ferrets. *J. Am. Vet. Med. Assoc.* 169, 961-964.

- Curran, M. D., Clarke, D. K. and Rima, B. K. (1991): The nucleotide sequence of the gene encoding the

attachment protein H of canine distemper virus. J. gen. Virol. 72:443-447.

- Domingo, M., Ferrer, L., Pumarola, M., Marco, A., Plana, J., Kennedy, S., Mc., Aliskey, M. and Rima, B. K. (1990): Morbillivirus in dolphins. Nature 348, 29.
- Gordon, M. T., Mee, A. P., Anderson, D. C. and Sharpe, P. T. (1992): Canine distemper virus transcripts sequenced from pagetic bone. J. Bone Miner. Res. 19 (2), 159-174.
- Hamburger, D., Griot, C., Zurbriggen, A., Örvell, C. and Vandeveld, M. (1991): Loss of virulence of canine distemper virus is associated with a structural change recognized by a monoclonal antibody. Experientia 47, 842-845.
- Hartley, W. J. (1974): A post-vaccinal inclusion body encephalitis in dogs. Vet. Pathol. 11, 301-312.
- Ho, S. N., Hunt, H. D., Horton R. M., Pullen, J., K. and Pease, L., R. (1989): Site-directed mutagenesis by overlap extension using the polymerase chain reaction. Gene 77, 51-59.
- Kennedy, S., Smyth, J. A., Cush, P. F., McCullough, S. J., Allan, G. M. and McQuaid, S. (1988): Viral distemper now found in porpoises. Nature 336, 21.
- Leary, W.E. (1994): A mysterious disease strikes Serengeti lions. N.Y. Times, June 1994.
- Mee, A. P., Webber, D. M., May, C., Bennett, D., Sharpe, P. T. and Anderson, D. C. (1992): Detection of canine distemper virus in bone cells in the metaphyses of distemper-infected dogs. J. Bone Miner. Res. 7, 829-834.
- Mitchell, W. J., Russel, S. E., Clark, D. K., Rima, B. K. and Appel, M. J. (1987): Identification of negative strand and positive strand RNA of canine distemper virus in animal tissues using single stranded RNA probes. J. Virol. Methods 18, 121-131.
- Montgomery, D. L., Donnelly, J.J., Shiver, J. J., Liu, M. A. and Ulmer, J. B. (1994): Protein expres-

sion in vivo by injection of polynucleotides. Current Opinion in Biotechnology, 5, 505-510.

Mori, T., Shin, Y.-S., Okita, M., Hirayama, N., Miyashita, N., Gemma, T., Kai, C. and Mikami, T.

- 5 (1994): The biological characterization of field isolates of canine distemper virus from Japan. J. gen. Virol. 75, 2403-2408.

Murray, G. (1994): New equine respiratory disease in Brisbane, Australia. Australian Animal Health Laboratory (AAHL).

10 Sambrook, J., Fritsch, E. F. and Maniatis T. (1989): Molecular cloning: a laboratory manual, 2nd ed., Cold Spring Harbor Laboratory, Cold spring Harbor, N. Y.

- Sidhu, M. S. , Husar, W., Cook, S. D., Downing, P. C. and Udem, S. A. (1993): Canine distemper terminal and intergenic non-protein coding nucleotide sequences: Completion of the entire CDV genome sequence. Virology 193, 66-72.

20 Tipold, A., Jaggi, A., Zurbriggen, A. and Vandeveld, M. (1994): Neurologische Symptome bei Hundes-taupe-eine klinische Studie. Wien. Tierärztl. Mschr. 81, 274-279.

Ulmer, J. B., Donnelly, J. J., Parker, S. E., Rhodes, G. H., Felgner, P. L., Dwarki V. J., Gromkowski, S. H., Deck, R. R., DeWitt, C. M., Friedman, A., Hawe, L. A., Leander, K. R., Martinez, D. Perry, H. C., Shiver, J. W., Montgomery, D. L. and Liu, M. A. (1993): Heterologous protection against influenza by injection of DNA encoding a viral protein. Science 259, 1745-1749.

- 30 Vandeveld, M., Zurbriggen, A., Steck, A. and Bichsel, P. (1986): Studies on the intrathecal humoral immune response in canine distemper encephalitis. J. Neuro-immunol. 11, 41-51.

Wolff, J. A., Ludtke, J. J., Ascadi, P., Williams, P. and Jani, A. (1992): Long-term persistence of plasmid DNA and foreign gene expression in mouse muscle. Hum. Mol. Genet. 1, 363-369.

Zurbriggen, A. and Vandeveld, M. (1984):
Morphological and immunocytochemical characterisation of
mixed glial cell cultures derived from neonatal canine
brain. Res. Vet. Science 36, 270-275.

5 Zurbriggen, A. Yamawaki, M. and Vandeveld,
M. (1993): Restricted canine distemper virus infection of
oligodendrocytes. Laboratory investigation 68, 277-284.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

5

(i) APPLICANT:

- (A) NAME: Wittek, Riccardo
- (B) STREET: Ch. de la mésange 1A
- (C) CITY: Vufflens-la-Ville
- (E) COUNTRY: Switzerland
- (F) POSTAL CODE (ZIP): 1302

10

(i) APPLICANT:

- (A) NAME: Zurbriggen, Andreas
- (B) STREET: Mühlestrasse 158
- (C) CITY: Münchenbuchsee
- (E) COUNTRY: Switzerland
- (F) POSTAL CODE (ZIP): 3053

15

(ii) TITLE OF INVENTION: Polynucleotide

20 Vaccine against Canine Distemper

(iii) NUMBER OF SEQUENCES: 23

(iv) COMPUTER READABLE FORM:

- (A) MEDIUM TYPE: Floppy disk
- (B) COMPUTER: IBM PC compatible
- (C) OPERATING SYSTEM: PC-DOS/MS-DOS
- (D) SOFTWARE: PatentIn Release

25

#1.0, Version #1.30 (EPO)

30

(v) CURRENT APPLICATION DATA:
APPLICATION NUMBER:

35

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20 nucleotides
- (B) TYPE: deoxyoligonucleotide
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

40

(ii) MOLECULE TYPE: DNA

45

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

- (A) ORGANISM:
- (D) DEVELOPMENTAL STAGE:
- (F) TISSUE TYPE:
- (G) CELL TYPE:

50

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

5': ACC AGA CAA AGT TGG CTA AG

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

5': ATA ATG AGT TTA GAA GGA GA

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 28 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

5': CAG TGG ATC CCC AAG TCA GAG TAA TAG A

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

5': GGG TCA CGT AAA CTC GGG CC

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

5': GGA CCT CCC GAG CAC GAC AC

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

5': TAG GAT TTC GAA GTT CCA GT

(2) INFORMATION FOR SEQ ID NO:7:

5 (i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 20 nucleotides
(B) TYPE: deoxyoligonucleotide
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

10 (ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

15 (iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:
(A) ORGANISM:
(D) DEVELOPMENTAL STAGE:
20 (F) TISSUE TYPE:
(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:
(A) LIBRARY:
25 (B) CLONE:
(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7

30 5': GCA TAC TAA GGT CGA TCC GG

(2) INFORMATION FOR SEQ ID NO:8:

35 (i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 30 nucleotides
(B) TYPE: deoxyoligonucleotide
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

40 (ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

45 (iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:
(A) ORGANISM:
(D) DEVELOPMENTAL STAGE:
50 (F) TISSUE TYPE:
(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:
- (C) SYNTHETIC: YES

5 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:8
5': CTG AGG ATC AGA AGT TTT GCC ATA CAC GCC

10 (2) INFORMATION FOR SEQ ID NO:9:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 20 nucleotides
 - (B) TYPE: deoxyoligonucleotide
 - (C) STRANDEDNESS: single
 - 15 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

20 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

- (A) ORGANISM:
- (D) DEVELOPMENTAL STAGE:
- 25 (F) TISSUE TYPE:
- (G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

- 30 (A) LIBRARY:
- (B) CLONE:
- (C) SYNTHETIC: YES

35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:9
5': TGC TGA CCG CTA TCT CAG AC

40 (2) INFORMATION FOR SEQ ID NO:10:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 20 nucleotides
 - (B) TYPE: deoxyoligonucleotide
 - (C) STRANDEDNESS: single
 - 45 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

50 (iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

- (A) ORGANISM:
- (D) DEVELOPMENTAL STAGE:
- (F) TISSUE TYPE:
- (G) CELL TYPE:

5

- (vii) IMMEDIATE SOURCE:
 - (A) LIBRARY:
 - (B) CLONE:
 - (C) SYNTHETIC: YES

10

- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:10

5': GGG CTA TCT AGA TGG ACC TC

15

- (2) INFORMATION FOR SEQ ID NO:11:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 27 nucleotides
 - (B) TYPE: deoxyoligonucleotide
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

20

- (ii) MOLECULE TYPE: DNA

25

- (iii) HYPOTHETICAL: NO

- (iv) ANTI-SENSE: NO

30

- (vi) ORIGINAL SOURCE:
 - (A) ORGANISM:
 - (D) DEVELOPMENTAL STAGE:
 - (F) TISSUE TYPE:
 - (G) CELL TYPE:

35

- (vii) IMMEDIATE SOURCE:
 - (A) LIBRARY:
 - (B) CLONE:
 - (C) SYNTHETIC: YES

40

- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:11

5' GGG GTA CCT CAG GGT TCA GAC CTA CCA 3'

45

- (2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:
 - (A) LENGTH: 27 nucleotides
 - (B) TYPE: deoxyoligonucleotide
 - (C) STRANDEDNESS: single
 - (D) TOPOLOGY: linear

50

(ii) MOLECULE TYPE: DNA
(iii) HYPOTHETICAL: NO
5 (iv) ANTI-SENSE: NO
(vi) ORIGINAL SOURCE:
 (A) ORGANISM:
 (D) DEVELOPMENTAL STAGE:
10 (F) TISSUE TYPE:
 (G) CELL TYPE:
(vii) IMMEDIATE SOURCE:
 (A) LIBRARY:
15 (B) CLONE:
 (C) SYNTHETIC: YES
(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12
20 5' GCG TCG ACG ACT GAT GTA ACA CTG GTC T 3'
(2) INFORMATION FOR SEQ ID NO:13:
25 (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 26 nucleotides
 (B) TYPE: deoxyoligonucleotide
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear
30 (ii) MOLECULE TYPE: DNA
(iii) HYPOTHETICAL: NO
35 (iv) ANTI-SENSE: NO
(vi) ORIGINAL SOURCE:
 (A) ORGANISM:
 (D) DEVELOPMENTAL STAGE:
40 (F) TISSUE TYPE:
 (G) CELL TYPE:
(vii) IMMEDIATE SOURCE:
 (A) LIBRARY:
45 (B) CLONE:
 (C) SYNTHETIC: YES
(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13
50 5' CGA CGC GTA GGG TCC AGG ACG TAG CA 3'
(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 20 nucleotides
 (B) TYPE: deoxyoligonucleotide
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

 (ii) MOLECULE TYPE: DNA

 (iii) HYPOTHETICAL: NO

 (iv) ANTI-SENSE: NO

 (vi) ORIGINAL SOURCE:
 (A) ORGANISM:
 (D) DEVELOPMENTAL STAGE:
 (F) TISSUE TYPE:
 (G) CELL TYPE:

 (vii) IMMEDIATE SOURCE:
 (A) LIBRARY:
 (B) CLONE:
 (C) SYNTHETIC: YES

 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:14

5' CAG GTT TAA ATG TCG GAT CG 3'

(2) INFORMATION FOR SEQ ID NO:15:

 (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 20 nucleotides
 (B) TYPE: deoxyoligonucleotide
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

 (ii) MOLECULE TYPE: DNA

 (iii) HYPOTHETICAL: NO

 (iv) ANTI-SENSE: NO

 (vi) ORIGINAL SOURCE:
 (A) ORGANISM:
 (D) DEVELOPMENTAL STAGE:
 (F) TISSUE TYPE:
 (G) CELL TYPE:

 (vii) IMMEDIATE SOURCE:
 (A) LIBRARY:
 (B) CLONE:
 (C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15

5' CGA TCC GAC ATT TAA ACC TG 3'

5

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:

10

- (A) LENGTH: 27 nucleotides
- (B) TYPE: deoxyoligonucleotide
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

15

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

20

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

25

- (A) ORGANISM:
- (D) DEVELOPMENTAL STAGE:
- (F) TISSUE TYPE:
- (G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

30

- (A) LIBRARY:
- (B) CLONE:
- (C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16

5' GCG TCG ACA AGA CGT GTG ACC AGA GTG 3'

35

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:

40

- (A) LENGTH: 26 nucleotides
- (B) TYPE: deoxyoligonucleotide
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

45

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

50

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

- (A) ORGANISM:
- (D) DEVELOPMENTAL STAGE:

37

(F) TISSUE TYPE:
(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:
(A) LIBRARY:
(B) CLONE:
(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17

5' GCG GTA CCA CAA TGC TCT CCT ACC AG 3'

(2) INFORMATION FOR SEQ ID NO:18:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 22 nucleotides
(B) TYPE: deoxyoligonucleotide
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:
(A) ORGANISM:
(D) DEVELOPMENTAL STAGE:
(F) TISSUE TYPE:
(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:
(A) LIBRARY:
(B) CLONE:
(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18

5' CAT ACA CTC CGT CTG AGA TAG C 3'

(2) INFORMATION FOR SEQ ID NO:19:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 22 nucleotides
(B) TYPE: deoxyoligonucleotide
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

5 (vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

10 (G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

15 (C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19

5' GCT ATC TCA GAC GGA GTG TAT G 3'

20

(2) INFORMATION FOR SEQ ID NO:20:

(i) SEQUENCE CHARACTERISTICS:

25

(A) LENGTH: 29 nucleotides

(B) TYPE: deoxyoligonucleotide

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

30

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

35

(vi) ORIGINAL SOURCE:

(A) ORGANISM:

(D) DEVELOPMENTAL STAGE:

(F) TISSUE TYPE:

40

(G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

45

(C) SYNTHETIC: YES

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20

5' GCG TCG ACT TAA CGG TTA CAT GAG AAT CT 3'

50

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 1678 nucleotides
 (B) TYPE: cDNA
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

5

(ii) MOLECULE TYPE: DNA

(iii) HYPOTHETICAL: NO

10

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM: CANINE DISTEMPER VI-
 RUS, STRAIN CDV A75/17

15

(D) DEVELOPMENTAL STAGE:
 (F) TISSUE TYPE:
 (G) CELL TYPE:

(vii) IMMEDIATE SOURCE:

20

(A) LIBRARY:
 (B) CLONE: N/CMV5 OR N/PCI

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21

25	AGGGTCAATG ATCCTACCTT AGAGAACAAG GTCAGGGTTC AGACCTACCA ATATGGCTAG	60
	CCTTCTTAAG AGCCTCACAT TATTCAAGAG GACTCGGGAC CAACCCCCAC TTGCCTCGGG	120
	CTCCGGAGGA GCAATCAGAG GGATAAAGCA TGTCATTATA GTCCTAATCC CGGGTGACTC	180
	AAGCATTGTT ACAAGATCTC GACTATTGGA TAGACTTGTT AGATTGGTCG GTGATCCGGA	240
	AATCAACGGG CCTAAATTAA CTGGGATTTT AATCAGTATC CTCTCCTTGT TCGTGGAAATC	300
30	CCCTGGACAG TTGATCCAGA GGATCATAGA CGACCCGTAT ATAAGCATCA AGTTAGTAGA	360
	GGATTCTGAG GCAGATGAGT TCTTCAAAT TGTAGACGAA GGTTCGAAAG CTCGAAGGACA	420
	ATTAGGCTGG TTGGAGAATA AGGATATTGT AGACATAGAA GTTGATGATG CTGAGCAATT	480
	CAATATATTG CTAGCTTCCA TCTTGGCCCA AATTTGGATC CTGCTAGCTA AAGCGGTGAC	540
35	TGCTCCTGAT ACTGCAGCCG ACTCGGAGAT GAGAAGGTGG ATTAAGTATA CCCAACAGAG	600
	ACGTGTGGTC GGGGAATTCA GAATGAACAA AATATGGCTT GATATTGTTA GAAACAGAAT	660
	TGCTGAGGAC TTATCTTTGA GCGGTTTCAT GGTGGCACTC ATCTTGGATA TCAAACGATC	720
	CCCAGGGAAC AAGCCTAGAA TTGCTGAAT GATTGTGAT ATAGATAACT ACATTGTGGA	780
40	AGCTGGATTA GCTAGTTTCA TCTTAACAT CAAATTGGCC ATTGAACTA TGTATCCGGC	840
	TCTTGGGTTG CATGAGTTT CCGGAGAGTT AACAACTATT GAATCCCTTA TGATGCTATA	900
	TCAACAGATG GGTGAACAG CACCGTACAT GGTATTCTG GAAATTTCTG TTCAGAACAA	960
	ATTTAGTGCA GGATCCTACC CATTGCTCTG GAGTTATGCT ATGGGAGTTG GTGTTGAACT	1020
	TGAAAACCTC ATGGGAGGGT TAAATTTCTG TAGATCCTAC TTTGATCCAG CTATTTCAG	1080
45	GCTCGGGCAA GAAATGGTTA GAAGATCTGC CGGCAAAGTA AGCTCTGCAC TTGCCCGCGA	1140
	GCTTGGCATC ACCAAGGAAG AGGCTCAACT AGTGTCAGAA ATAGCATCCA AGACAACGGA	1200
	GGACCGGACG ATTCCGCGTG CTGGTCCCAA GCAATCTCAA ATCACTTTTC TGCATCAGA	1260
	AAGATCCGAA GTCACTAATC AACAAACCCC AACCATCAAC AAGAGGTCCG AAAACCAAGG	1320
	AGGAGACAAA TACCCATCC ACTTCAGTGA TGAACGGTTT CCAGGGTATA CCCCAGATGT	1380
	CAACAGCTCC GAATGGAGTG AATCAGCTA TGATACCAA ACTATTCAAG ATGATGGAAA	1440
50	CGACGATGAC CGGAAATCGA TGGAAAGCAAT CGCCAAGATG AGAATGCTTA CTAAGATGCT	1500
	CAGTCAACCT GGGACCAGTG AAGAGAGTTC TCCTGTCTAT AATGATAGAG AGCTACTCAA	1560
	TTAAATATTC AAGACCAGTG TTACATCAGT CAACGATTCT CCTTCTAAAC TCATTATA	1620
		1678

55 (2) INFORMATION FOR SEQUENCE ID NO: 22

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 2198
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

60

- (ii) MOLECULAR TYPE: other nucleic acid
(A) DESCRIPTION: /desc = "deoxynucleotide"
- 5 (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (v) FRAGMENT TYPE: internal
- 10 (vi) ORIGINAL SOURCE:
(A) ORGANISM: Canine distemper virus
(B) STRAIN: A75/17
- 15 (viii) POSITION IN GENOME:
(B) MAP POSITION: F gene position is 5' end of F
mRNA
(C) UNITS: bp
- 20 (ix) FEATURE:
(A) NAME/KEY: mRNA
(B) LOCATION: complement (1....2198)

```
25 AGGGTCCAGG ACGTAGCAAG CCTACAGGCC AACCAAGTCC ACCAACTCTA GGCCGGGCAG 60
   GAACCCCCAC GAACAGACAA GCCCATGCA CAACAAAATC CCAAAAAGGT CCAACACCCG 120
   AAAACACACC CAACAAGACC TCCCCCACA ACACAGCACC AAATCCGCCG AGACCAAGAC 180
   ATCCCAAGCA CGACACAGCA CAACATCGGC TCGGCGATCC ACGCACCATG GTCCTCTAAC 240
   ATCGGACAGG CCCATCCACT ACATCATGAA CAGGATCAGG TCCTGCAAGC AAGCCAGCCA 300
   CAGATCGGAT AACATCCCGG CTCACGGAGA CCATGAGGGC ACCATCCATC ACACACCAGG 360
   GAGTGTCTCC CAAGGAGCGG GATCCCGGCT CAAAAGGCGG CAATCCAATG CAACCAACTC 420
   AGGCTCTCAG TGCACCTGGT TAGTCCTATG GTGCATTGGA ATAGCCAGTC TCTTTCTTTG 480
   TTCTAAGGCT CAGATACATT GGAATAATTT GTCAACTATT GGGATTATCG GGACTGACAG 540
   TGTCCATTAT AAGATCATGA CTAGACCCAG TCACCCAGTAC TTGGTCATAA AACTAATGCC 600
   TAATGTTTCA CTTATAGATA ATTGTACCAA AGCAGAATTA GGTGAGTATG AGAAATTATT 660
   AAATTCAGTC CTCGAGCCAA TCAATCAAGC TTTGACTCTA ATGACCAAGA ATGTGAAGCC 720
   CCTACAGTCA GTAGGGTCAG GTAGGAGACA AAGGCGTTTT GCAGGAGTGG TGCTTGCAGG 780
   TGCAGCTTTA GGAGTAGCCA CAGCTGCACA AATCACTGCA GGGATAGCTT TACATCAATC 840
   CAACCTCAAT GCTCAAGCAA TCCAATCTCT GAGAACTAGC CTTGAACAGT CCAACAAGGC 900
   TATAGAAGAA ATTAGGGAGG CAACCCAGGA AACCGTCATT GCCGTTCAGG GAGTTCAGGA 960
   TTACGTCAAT AATGAACTCG TCCCTGCTAT GCAACATATG TCGTGTGAAT TAGTTGGGCA 1020
   GAGATTAGGG TTAAACTGCT TTAGGTATTA TACCGAGTTG TTGTCAATAT TTGGCCCCAG 1080
   TTTACGTGAT CCTATTTCAG CCGAGATATC AATTCAAGCA CTGAGTTATG CTCTTGGGGG 1140
   AGAAATTCAT AAGATACTTG AGAAGTTGGG ATATTCTGGA AATGATATGA TTGCAATTTT 1200
   GGAGAGTCGG GGGATAAAAA CAAAAATAAC CCATGTTGAT CTCCCCGGGA AACTCATCAT 1260
   CTTAAGTATC TCATACCCAA CTTTATCAGA AGTCAAGGGG GTCATAGTCC ACAGACTGGA 1320
   AGCAGTTTCT TATAATATAG GGTACAGGGA GTGGTACACC ACTGTCTCGA GGTATGTTGC 1380
   AACTAATGGT TACTTAATAT CTAATTTTGA TGAGTCACCC TGTGTATTTC TCTCAGAAATC 1440
   AGCCATTTGT AGCCAGAAGT CCCTATACCC CATGAGCCCG CTTCTACAAC AATGCATTAG 1500
   GGGTGACACT TCATCTTGTG CTCGGACCTT GGTGTCTGGG ACGATGGGCA ACAAGTTTAT 1560
   TCTGTCAAAA GGTAATATCG TCGCAATTG TGCTTCTATA CTGTGTAAGT GTTATAGCAC 1620
   AGGCACAATT ATCAATCAGA GTCCTGATAA ATTGCTGACA TTTATTGCC TCCGGTACCTG 1680
   CCCACTGGTT GAGATAGATG GTGTAATAT CCAGGTGGA GGGAGGCAAT ACCCTGATAT 1740
   GGTATACGAA AGCAAAGTTG CCTTAGGCCC TGCTATATCA CTTGAGAGGT TAGATGTAGG 1800
   TACAAATTTA GGAACGCCCT TTAAGAAACT GGATGATGCT AAGGTACTGA TAGACTCCTC 1860
   TAACCAGATC CTTGAGACGG TTAGGCGCTC TTCCTTAAAT TTTGGCAGTC TTCTCAGCGT 1920
   TCCCATATTA ATATGTACAG CCCTGGCTTT GTTGTGCTG ATTTACTGCT GTAAAAGACG 1980
   CTACCAACAG AACTCAAGC AGAATGCTAA GGTGATCCG ACATTAAAC CTGATTTGAC 2040
   TTGAACCTCG AAATCCTATG TAAGATCACT CTAAAGCACT CTGGTCACAC GTCTTACCCG 2100
   60 ATTGTCAGGC TTGAAATCTA TAAATCCCCC CCAATTTTCT TCAAAAGCTA TCAAACTACA 2160
   ACAAATAGTG GAGAGGACTG ACTACGATTA TCGTAATT 2198
```

(2) INFORMATION FOR SEQUENCE ID NO: 23

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 1969

(B) TYPE: nucleic acid

(C) STRANDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULAR TYPE: other nucleic acid

(A) DESCRIPTION: /desc =

"deoxynucleotide"

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(A) ORGANISM: Canine distemper virus

(B) STRAIN: A75/17

(viii) POSITION IN GENOME:

(B) MAP POSITION: H gene position is

25 5' end of H mRNA

(C) UNITS: bp

(ix) FEATURE:

(A) NAME/KEY: mRNA

(B) LOCATION: complement (1....1969)

```

AGGGCTCAGG TAGTCCAACA ATGCTCTCCT ACCAGGACAA GGTGAGTGCC TTCTATAAGG    60
ATAATGCAAG AGCTAATTCA TCCAAGCTAT CCTTAGTGAC AGAAGAGCAA GGGGGCAGGA    120
35 GACCACCCTA TTTGCTGTTT GTCCTTCTCA TCCTACTGGT TGGAAATCATG GCCTTGCTTG    180
CTATCACTGG AGTTCGATTI CACCAAGTAT CAACTAGCAA TATGGAATTT AGCAGATTGC    240
TGAAAGAGGA TATGGAGAAA TCAGAGGCCG TACATCACCA AGTCATAGAT GTCTTGACAC    300
CGCTCTTCAA AATTATTGGA GATGAGATTG GGTACGGTT GCCACAAAAA CTAAACGAGA    360
TCAAACAATT TATCCTTCAA AAGACAAACT TCTTCAATCC GAACAGGGAG TTCGACTTCC    420
40 GCGATCTCCA CTGGTGCATT AACCCACCTA GTAAGATCAA AGTGAATTTT ACTAATTACT    480
GCGATACAAAT TGGGATCAGA AAATCTATTG CATCGGCAGC AAATCCTATC CTTTATCAG    540
CACTCTCCGG AGGCAGAGGT GACATATTCC CACCATACAG ATGCAGTGGG GCTACTACTT    600
CAGTAGGCAG AGTTTCCCC CTATCAGTAT CATTGTCCAT GTCTTTGATC TCAAGACAT    660
CAGAGATAAT CAATATGCTA ACCGCTATCT CAGACGGAGT GTATGGTAAA ACTTATTGTC    720

```

	TAGTTCATGA	TTATATTGAA	GGGGGGTTCG	ACACGCAAAA	GATTCGAGTC	TTTGAGATAG	780
	GGTTCATCAA	ACGGTGGCTG	AATGACATGC	CATTACTCCA	GACAACCAAC	TATATGGTCC	840
	TCCCGGAGAA	TTCCAAAGCC	AAGGTATGTA	CTATAGCGGT	GGGCGAGTTG	ACACTGGCTT	900
	CCTTGTGTGT	AGATGAGAGC	ACCGTATTGT	TATATCATGA	CAGCGATGGT	TCACAAGATG	960
5	GTATTCTAGT	GGTGACGCTG	GGAATATTG	GGGCAACACC	TATGGATCAA	GTTGAAGAGG	1020
	TGATACCTGT	TGCTCACCCA	TCAGTAGAAA	AAATACATAT	AACAAATCAC	CGTGGGTTCA	1080
	TAAAAGATTG	AATAGCAACC	TGGATGGTGC	CTGCATTGGT	ATCTGAGAAA	CAAGAGGAAC	1140
	AAAAAAATTG	TCTGGAGTCG	GCTTGTCAAA	GAAAATCCTA	CCCTATGTGC	AACCAAACGT	1200
	CATGGGAACC	CTTTGGAGGA	GGACAGTTGC	CATCTTATGG	GCGGTTGACA	TTACCTCTAG	1260
10	ATCCAAGCAT	TGACCTTCAA	CTTAACATCT	CGTTTACATA	CGGTCCGGCT	ATACTGAATG	1320
	GAGACGGTAT	GGATTATTAT	GAAAGCCAC	TTTTGGACTC	CGGATGGCTT	ACCATTCCCC	1380
	CCAAGAACGG	AACAGTCCTT	GGATTGATAA	ACAAAGCAAG	TAGAGGAGAC	CAATCCACTG	1440
	TAAATCCCCA	TGTGTTTACA	TTTGCGCCCA	GGGAATCAAG	TGGAAATTGT	TATTTACCTA	1500
	TTCAAACATC	CCAGATTATG	GATAAAGATG	TCCTTACTGA	GTCCAATTGA	GTGGTGTTGC	1560
15	CTACACAGAA	TTTTAGATAT	GTCATAGCAA	CATATGATAT	ATCCCGGGGC	GATCATGCCA	1620
	TTGTTTATTA	TGTTTATGAC	CCAATCCGGG	CGATTTCTTA	TACGTACCCA	TTTAGACTAA	1680
	CTACCAAGGG	TAGACCTGAT	TTCCTAAGGA	TTGAATGTTT	TGTGTGGGAT	GACGATTTGT	1740
	GGTGTACCA	ATTTTACCGA	TTGAGGCTG	ACAGCACCAA	CTCTACAACC	AGTGTGAGAA	1800
	ATTTAGTCCG	TATAAGATTG	TCATGTAATC	GTTCAAACCC	TTGACAGTAT	GATGATACAC	1860
20	ATTTCAATTG	GACTTAGGTA	TGATGACTGT	GGTGAGAAAT	TCCTTACCGA	CGATTGAATT	1920
	AAACCATCTC	CAGCATTATA	AAAAAACTAA	GGATCCAGGA	TCCTTTTAG		1969

CLAIMS

1. A nucleic acid construct comprising one or
5 more canine distemper virus gene, wherein said nucleic
acid construct is capable of inducing the expression of
an antigenic canine distemper virus gene product which
induces a canine distemper virus specific immune response
upon introduction of said nucleic acid construct into
10 animal tissue *in vivo* and resultant uptake of the nucleic
acid construct by the cells which express the encoded ca-
nine distemper virus gene.

2. A nucleic acid construct according to
15 Claim 1, wherein the canine distemper virus gene encodes
the nucleocapsid (N) protein, the phosphoprotein (P), the
matrix (M) protein, the fusion (F) protein, the hemagglu-
tinin (H) protein, or the large (L) protein.

20 3. A nucleic acid construct according to
Claim 1 or 2, wherein the canine distemper virus gene en-
codes the nucleocapsid (N) protein, the fusion (F) pro-
tein, or the hemagglutinin (H) protein.

25 4. A DNA construct according to anyone of
Claims 1 to 3, which is the plasmid N/CMV5 or N/pCI,
which encode the nucleocapsid (N) protein, the plasmid
H/CMV5 or H/pCI, which encode the hemagglutinin (H) pro-
tein, or the plasmid F/CMV5 or F/pCI which encode the fu-
30 sion (F) protein of canine distemper virus strain A75/17.

5. A polynucleotide vaccine comprising an ef-
fective amount of a DNA or RNA construct according to
anyone of Claims 1 to 4 and a physiologically acceptable
35 carrier.

6. A polynucleotide vaccine according to Claim 5 which induces neutralizing antibodies against canine distemper virus, canine distemper virus specific cytotoxic lymphocytes, or protective immune responses upon introduction of said vaccine into animal tissue *in vivo*, wherein the animal is a mammal, carnivore, in particular a dog, or a human.

7. A polynucleotide vaccine according to Claim 5 or 6 comprising one or more of the plasmids selected from N/CMV5 or N/pCI, which encode the nucleocapsid (N) protein, H/CMV5 or H/pCI, which encode the hemagglutinin (H) protein, or F/CMV5 or F/pCI which encode the fusion (F) protein of canine distemper virus strain A75/17 and a vaccine carrier.

8. A polynucleotide vaccine according to any one of Claims 5 to 7 additionally comprising further components to form a multivalent vaccine.

9. A method for protecting an animal susceptible to canine distemper infection against disease by canine distemper virus which comprises immunization of said animal with a prophylactically effective amount of a polynucleotide vaccine of anyone of claims 5 to 8.

10. A method according to Claim 9, wherein the animal is a mammal, such as a carnivore, in particular a dog.

11. A method according to Claim 9 or 10, wherein at least one polynucleotide is administered directly into the animal tissue *in vivo*.

12. A method according to Claims anyone of 9 to 11, wherein the polynucleotide is administered either in naked form in a physiologically acceptable solution,

or contained in a liposome, or in a mixture with an adjuvant or a transfection facilitating agent.

13. A method for using a canine distemper virus gene to induce an immune response in vivo which comprises:

a) isolating the gene

b) linking the gene to regulatory sequences such that the gene is operatively linked to control sequences which, when introduced into a living tissue, direct the transcription initiation and subsequent translation of the gene, and

c) introducing the gene into a living tissue of an animal susceptible to canine distemper.

15

14. A method according to Claim 13, which comprises multiple introduction of the canine distemper virus gene for boosting the immune response.

20

15. A method according to Claim 13 or 14, wherein the canine distemper virus gene encodes the nucleocapsid (N) protein, the hemagglutinin (H) protein, or the fusion (F) protein of canine distemper virus strain A75/17.

25

16. A method according to anyone of Claims 13 to 15, wherein the canine distemper virus gene product for immunization is selected from the plasmids F/CMV5 or F/pCI, which encode the fusion (F) protein, H/CMV5 or H/pCI, which encode the hemagglutinin (H) protein, or N/CMV5 or N/pCI which encode the nucleocapsid protein of canine distemper virus strain A75/17.

30

17. A composition of nucleic acid constructs encoding canine distemper genes from more than one canine distemper strain.

35

18. The use of an isolated canine distemper virus gene operatively linked to one or more control sequences for the preparation of a vaccine for use in immunization against disease by canine distemper virus.

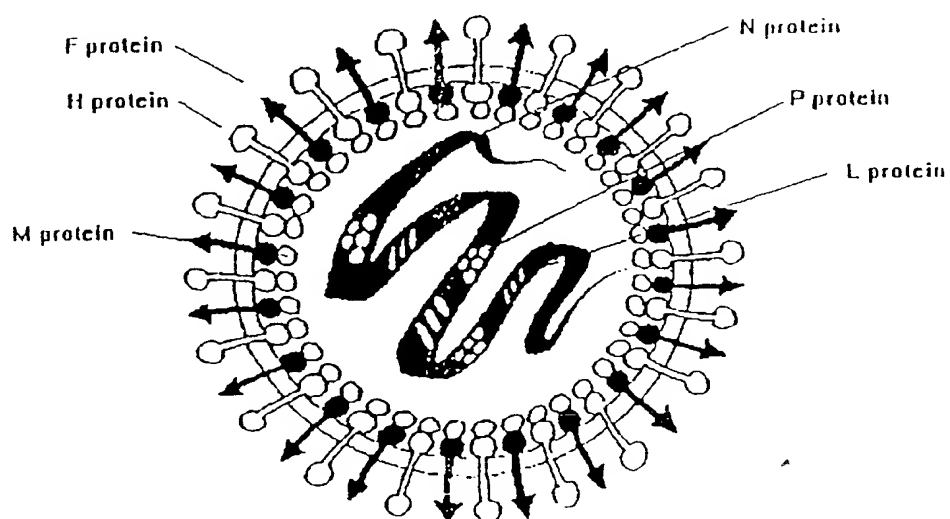


Fig. 1

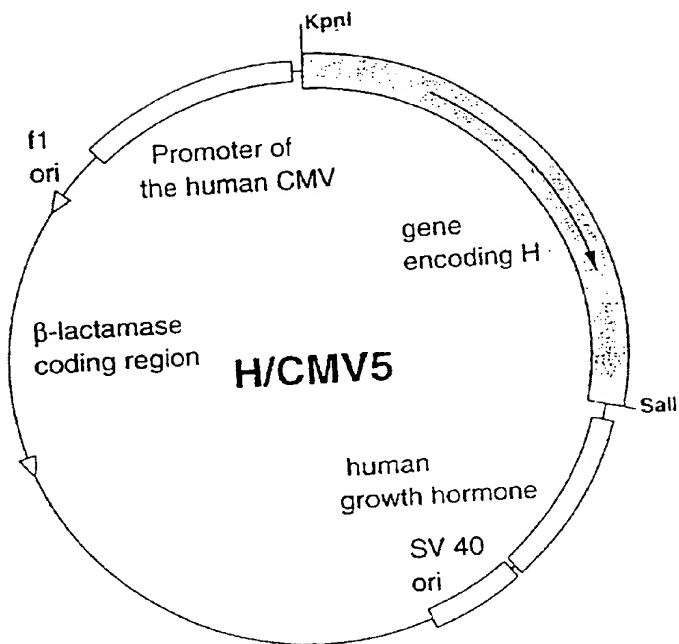


Fig. 2

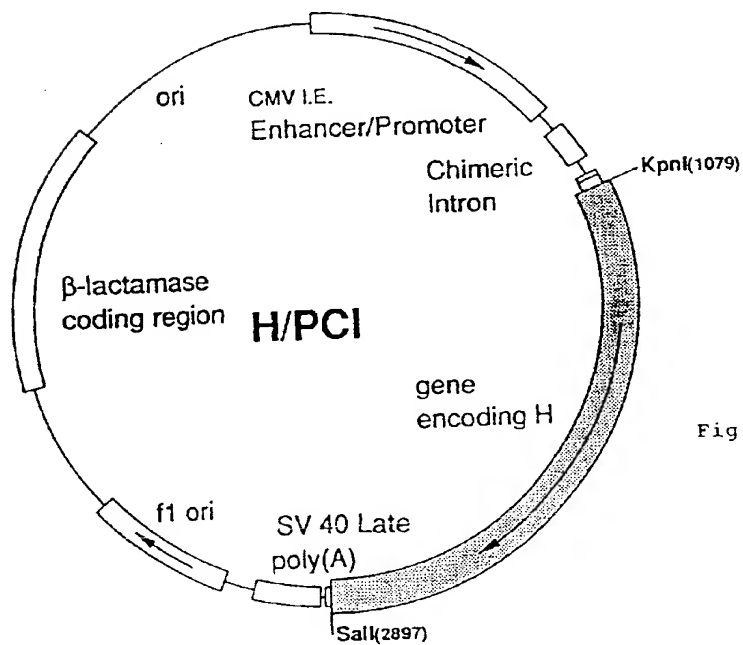


Fig. 3

3 / 6

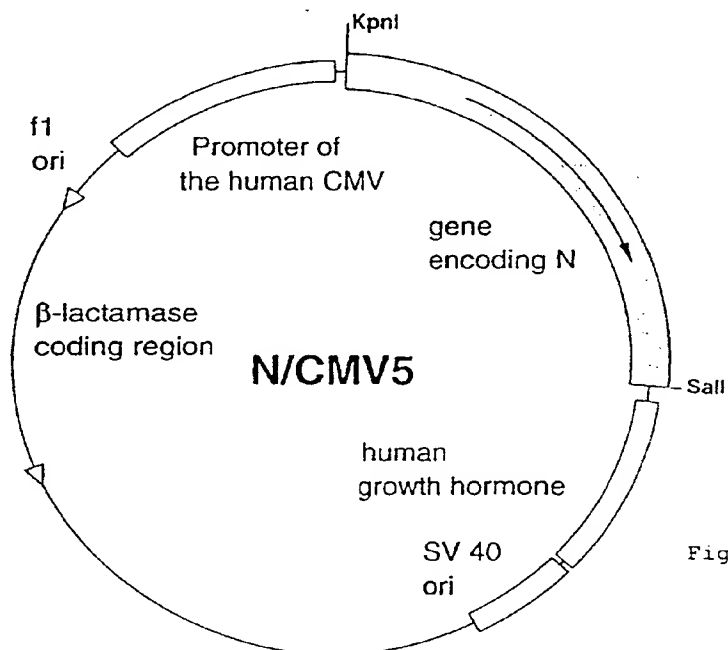


Fig. 4

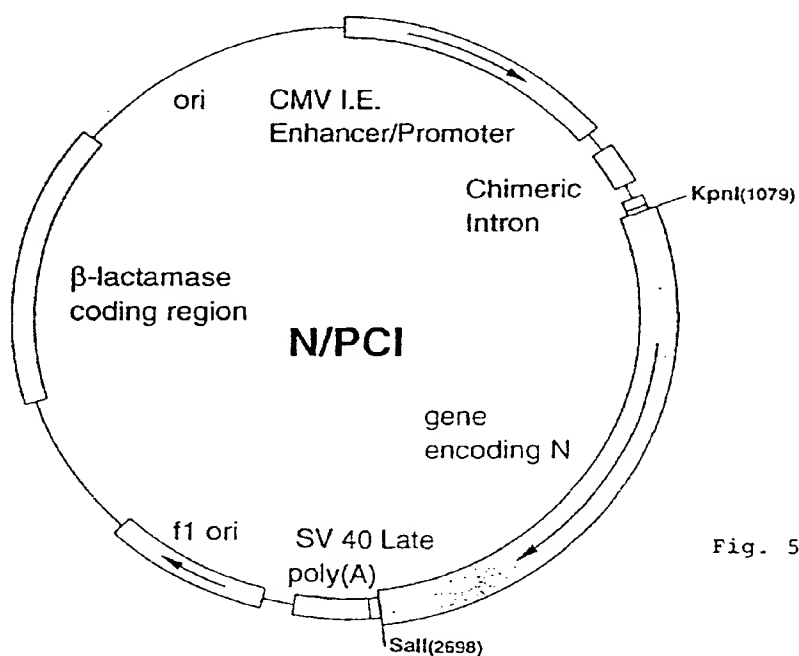


Fig. 5

4/6

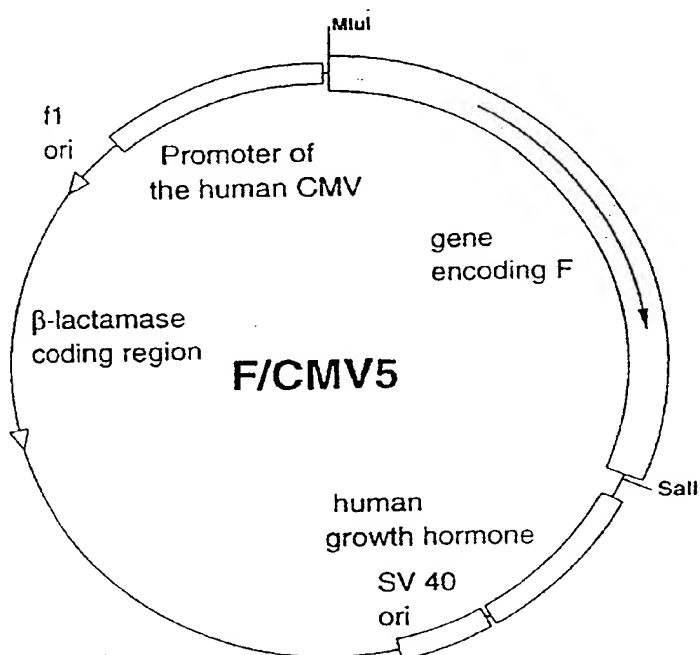


Fig. 6

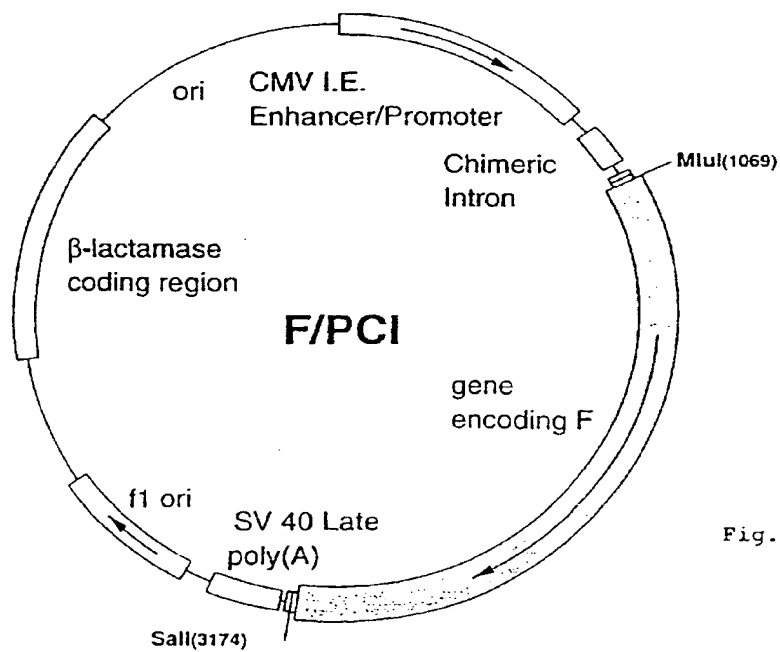


Fig. 7

5/6

CTL assays

after 2nd immunization

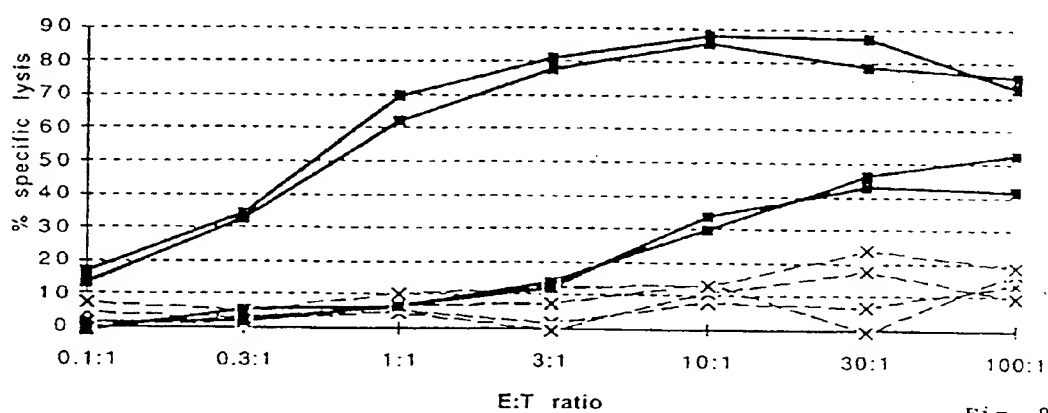
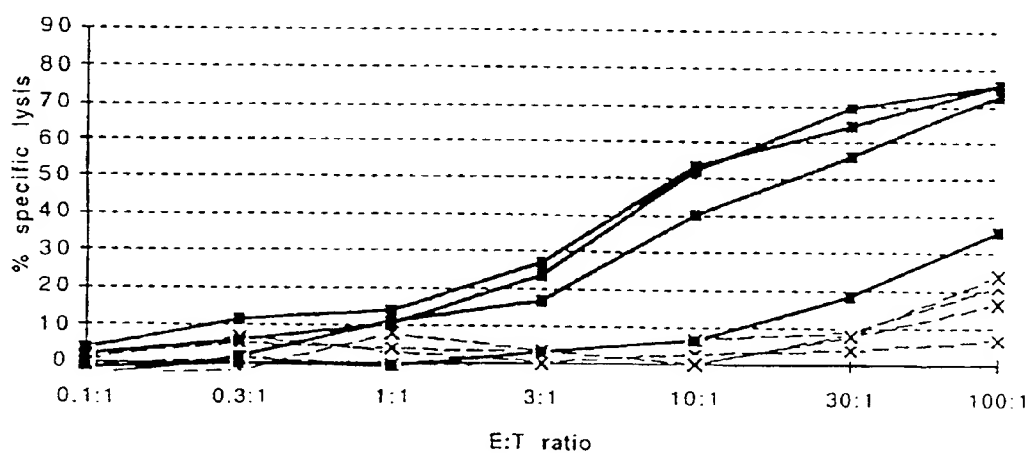


Fig. 8

after 3rd immunization



x-----x mice immunized with empty vector

■-----■ mice immunized with plasmid N/pCI

Fig. 9

SUBSTITUTE SHEET (RULE 26)

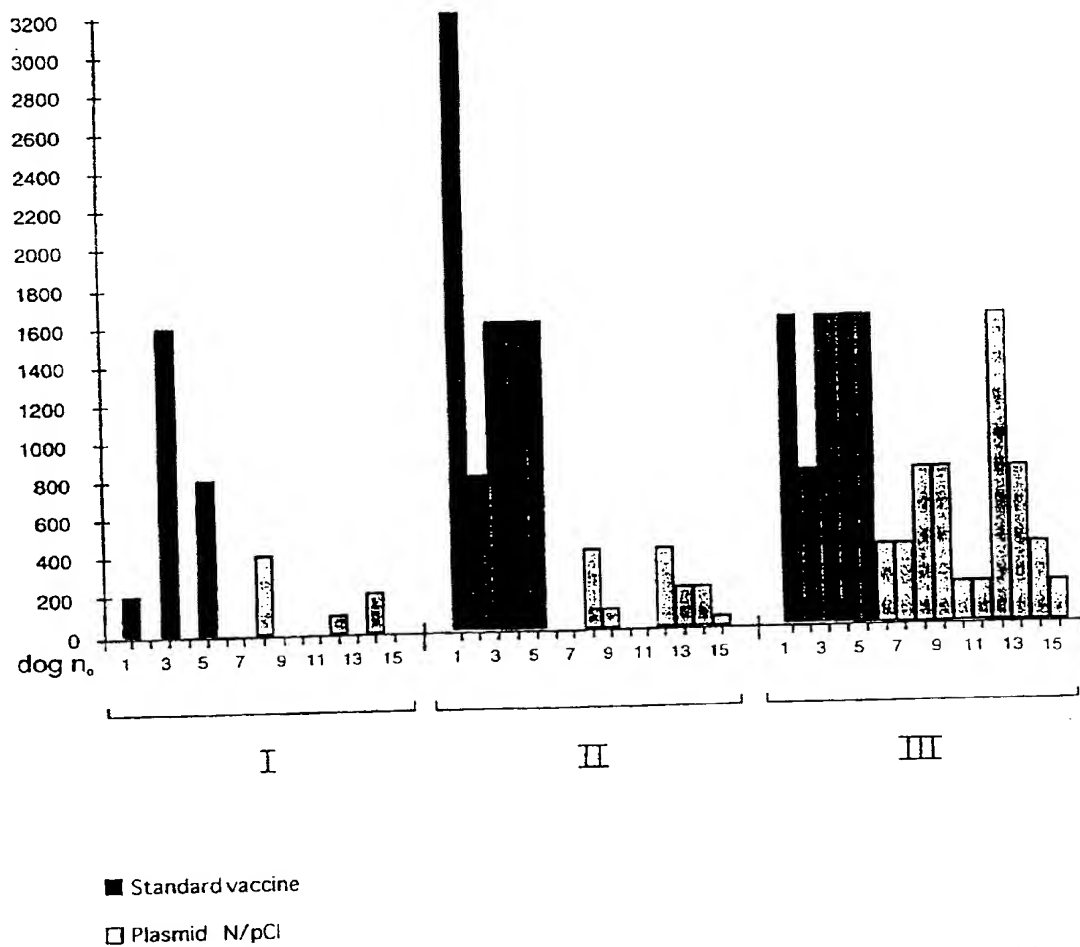


Fig. 10

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

Intern. Application No.
PCT/IB 97/00444A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C12N15/45 A61K31/70 A61K39/175

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C12N A61K C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95 27780 A (VIROGENETICS CORPORATION) 19 October 1995 see page 108, line 19 - page 121, line 16 ---	1-18
A	VETERINARY MICROBIOLOGY, vol. 44, no. 2-4, 1995, pages 211-217, XP000601698 M.STETTLER AND A.ZURBRIGGEN: "Nucleotide and deduced amino acid sequences of the nucleocapsidprotein of the virulent A75/17-CDV strain of canine distemper virus" see the whole document --- -/--	1-18



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- * "A" document defining the general state of the art which is not considered to be of particular relevance
- * "E" earlier document but published on or after the international filing date
- * "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- * "O" document referring to an oral disclosure, use, exhibition or other means
- * "P" document published prior to the international filing date but later than the priority date claimed

* "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

* "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

* "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

* "&" document member of the same patent family

Date of the actual completion of the international search

5 August 1997

Date of mailing of the international search report

14.08.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Cupido, M

INTERNATIONAL SEARCH REPORT

Int. Appl. No.
PCT/IB 97/00444

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SCHWEIZER ARCHIV FÜR TIERHEILKUNDE, vol. 138, no. 2, February 1996, pages 99-103, XP000601356 H.U.GRABER ET AL.: "RT-PCR:Ein Hilfsmittel zur Herstellung von Klonen für die Staupeforschung" see the whole document ---	1-18
A	AMERICAN JOURNAL OF VETERINARY RESEARCH, vol. 54, no. 9, September 1993, pages 1457-1461, XP000601924 A.ZURBRIGGEN ET AL.: "In situ hybridization of virulent canine distemper virus in brain tissue, using digoxigenin-labeled probes" see the whole document ---	1-18
A	DNA AND CELL BIOLOGY, vol. 12, no. 9, November 1993, pages 777-783, XP000565708 D.L.MONTGOMERY ET AL.: "Heterologous and homologous protection against influenza A by DNA vaccination: Optimizing of DNA vectors" see the whole document -----	1-16

Form PCT/ISA/218 (continuation of second sheet) (July 1992)

page 2 of 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00444

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

Remark: Although claim(s) 9-16 is(are) directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

2. ☐ Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IB 97/00444

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9527780 A	19-10-95	AU 2283395 A	30-10-95
		CA 2187207 A	19-10-95
		EP 0759072 A	26-02-97

Form PCT/ISA/210 (patent family annex) (July 1992)